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16. ABSTRACT

A YEAR long search for pathogens in sludge products that could be distributed and marketed (D&M) to the general public was completed recently for the U.S. Environmental Protection Agency by the County Sanitation Districts of Los Angeles County. The study analyzed 498 samples of sludge products that were taken serially from 26 locations in 17 states over a period of one year. Each sample was analyzed for over 15 pathogen and indicator microorganism groups. The study found that the sludge products were remarkably free of pathogenic viruses and viable parasitic ova.

The study did find, however, that the ubiquitous pathogenic bacterium *Salmonella* was detected in a significant number of the samples. *Yersinia* was found in samples of sludges from a far fewer number of the locations. As might be expected, indicator microorganisms were found in all samples. The occurrence of *Salmonella* and *Yersinia* in D&M products may represent a possible health problem under certain scenarios. However, the study was designed only to determine the occurrence of pathogens in the D&M products. The possible health effects to users of the products was not within the scope of the study and no conclusions could be developed on actual health risks.

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DETERMINING PATHOGEN LEVELS IN SLUDGE PRODUCTS

An EPA-funded study analyzed 498 samples of composts and dried sludge products from 26 locations.

Nora Goldstein, William A. Yanko, John M. Walker and Walter Jakubowski

A YEAR long search for pathogens in sludge products that could be distributed and marketed (D&M) to the general public was completed recently for the U.S. Environmental Protection Agency by the County Sanitation Districts of Los Angeles County. The study analyzed 498 samples of sludge products that were taken serially from 26 locations in 17 states over a period of one year. Each sample was analyzed for over 15 pathogen and indicator microorganism groups. The study found that the sludge products were remarkably free of pathogenic viruses and viable parasitic ova.

The study did find, however, that the ubiquitous pathogenic bacterium *Salmonella* was detected in a significant number of the samples. *Yersinia* was found in samples of sludges from a far fewer number of the locations. As might be expected, indicator microorganisms were found in all samples. The occurrence of *Salmonella* and *Yersinia* in D&M products may represent a possible health problem under certain scenarios. However, the study was designed only to determine the occurrence of pathogens in the D&M products. The possible health effects to users of the products was not within the scope of the study and no conclusions could be developed on actual health risks.

Furthermore, the exact significance of the presence of *Salmonella* is unclear because this pathogen occurs commonly in the environment, and has the capability to regrow in previously "clean" substrate such as disinfected sludge products and food. The significance of the *Yersinia* occurrence also is unclear. Some species of this bacterium are pathogenic and some are not. Further analysis of a small sample of the *Yersinia* species isolated in this study did not reveal them to be pathogenic.

Review of the data gathered in this recent investigation is very encouraging for compost facilities. While *Salmonella* was detected, one of the facilities studied has found that through modified composting practices (explained later in this article), it can be controlled.

Table I. Weekly Sampling Sites*

Location	Sampling Point
1. Pennsylvania Static Pile Composting Facility	a) Giveaway Bin b) Screened Compost
2. California Windrow Composting Facility	a) Final Sawdust Compost b) Final Recycle Compost c) Bagged Compost d) Bagged Compost with Rice Hull e) Bagged Compost with Sawdust f) Bagged Compost with Bark and Redwood

*Sampled weekly from Jan. 1986-Jan. 1987.

RESEARCH OBJECTIVE

The San Jose Creek Water Quality Laboratory (part of the Los Angeles County Sanitation Districts) in Whittier, California, conducted the study under contract with EPA's Health Effects Research Laboratory in Cincinnati, Ohio. The basic objective of the search was to determine the types and concentrations of various non-pathogenic indicator microorganisms and pathogenic microorganisms that may be present in distributed and marketed sludges. The findings were published in a report entitled: "Occurrence of Pathogens In Distribution And Marketing Municipal Sludges" (NTIS: PB88-154-273/AS; $25.95). The study also surveyed the presence of chemicals in distributed and marketed sludges. Those results appear in a separate report, "Trace Organics and Inorganics In Distribution & Marketing Municipal Sludges" (NTIS: PB88-160-585; $25.95).

SLUDGE PRODUCT SAMPLING

Composts and other sludge products were sampled from a total of 26 facilities (see Tables I and II). Composts (treated by processes to further reduce pathogen-PFRP) from two facilities—a windrow operation and an aerated static pile operation—were sampled weekly for one year. Material, treated either by a PFRP or PSRP, from the other 24

facilities was sampled on a bimonthly basis for one year. Samples were analyzed for a variety of bacteria, viruses, parasites and fungi in the indicator and pathogen categories (see Table III).

Five compost products were sampled weekly at the windrow facility. They included the final compost produced, and four commercially marketed, compost-based soil amendment products. The two weekly sampling points at the static pile facility were the final screened compost that was utilized in a number of bulk distribution programs and the "giveaway bin" that contained unscreened compost available to the public for home use. Operators at both facilities assured the researchers that they were following recommended guidelines for composting (i.e. meeting time/temperature requirements for a PFRP product).

STUDY RESULTS

Most classes of pathogens were not detected in most of the 354 sludge compost samples taken from the two facilities tested each week. The only potential pathogens that were detected were bacterial, including *Salmonella*, *Yersinia*, and toxigenic *Escherichia coli*. On the other hand, the indicator microorganisms were frequently detected at high concentrations. Tremendous indicator variability was observed with some concentrations varying by as much as 10 orders of magnitude, notes the report. It states:

Data from the windrow site grouped into two strata. The first stratum included the final compost and the commercial product containing only screened final compost. Average concentrations of microorganisms were higher in the bagged compost than in the field compost samples but the differences were not significant at the 95 percent confidence limits (C.L.). The second grouping of data consisted of bagged commercial products containing additional amendments (added to the material after the compost operation); these products contained significantly higher concentrations of microorganisms than those in the first stratum.

Analysis of the data from the static pile composting facility indicated that these two sampling points were also significantly different. The screened compost contained higher levels of bacteria than the material in the giveaway bin. Some, but not all, of the difference could be accounted for by the presence of the woodchips in the unscreened compost.

Results from the 24 facilities sampled on a bimonthly basis also showed a great deal of variation in microbial densities. Air dried sludges often contained lower concentrations of enteric bacteria than composted sludges and as a group, were significantly lower than static pile composting sites. *Salmonella*, *Yersinia* and toxigenic *E. Coli* were randomly isolated in the various sludge products from the facilities sampled bimonthly, generally at low levels and at lower levels than in the products from the two facilities that were sampled weekly.

CONCLUSIONS

Some of the conclusions provided in the report are:

- No health hazard was found associated with respect to parasitic helminth ova, *Campylobacter* (a bacterium that can cause gastroenteritis, or enteric viruses. In fact, no campylobacters or viable parasitic helminth ova were detected in any sample and viruses were detected in only two of the 498 samples. The test for campylobacters in compost was relatively ineffective but other available data suggest these bacteria would not survive composting or air drying. Helminth ova were detected regularly but no indications of viability were observed. No protozoan cysts were found.
- All of the sewage sludge products examined were found to contain variable concen-

Table II. Bimonthly Sampling Sites*

Location	Process	Classification
Maine	Static Pile	PFRP
New Jersey	In-Vessel	PFRP
Maryland	Static Pile	PFRP
Virginia	Static Pile	PFRP
Virginia	Aerated Windrow	PFRP
North Carolina	Static Pile	PFRP
Florida	Drying Bed	PSRP
Florida	Aerobic Digestion-Air Dried	PSRP
Georgia	Heat Drying	PFRP
Indiana	Static Pile	PFRP
Indiana	Zimpro/Filter Press	PFRP
Texas	Air Dried	PSRP
Kansas	Air Dried	PSRP
Kansas	Windrow	PFRP
Colorado	Air Dried	PSRP
Utah	Aerobic Digestion-Air Dried	PSRP
Montana	Proprietary	PFRP
Colorado	Aerated Windrow	PFRP
California	Windrow	PFRP
California	Static Pile	PFRP
California	Air Dried	PSRP
Arizona	Air Dried	PSRP
Arizona	Air Dried	PSRP
Oregon	In-Vessel	PFRP

**Sampled each every two months from April 1986–April 1987.*
PFRP: Process to Further Reduce Pathogens
PSRP: Process to Significantly Reduce Pathogens
Note: Air dried sludges were anaerobically digested unless otherwise stated.

Table III. Microorganism Categories Selected for Analysis

Indicators	Pathogens
Total coliform	Enterotoxigenic *E. coli*
Fecal coliform	Total enteric bacteria
Fecal streptococci	*Salmonella*
Aerobic plate count	*Campylobacter*
Anaerobic plate count	*Yersinia*
Total Fungi	*Ascaris ova*
Thermophilic fungi	Total parasites
Bacteriophage	Total enteric viruses

Researchers found no reports of anyone ever getting sick from using a sludge compost-based fertilizer or soil amendment product.

Authors of this article are very encouraged that "there were no significant problems with viruses and parasites—major groups of organisms that were thought could be a problem."

trations of non-pathogenic indicator microorganisms. Some products contained bacterial pathogens—most specifically *Salmonella*—at relatively high frequencies and levels. Variability of microorganism concentrations was often great between different facilities and between different samples from the same facility. Many of the observed trends would not have been detected without a large number of samples collected over a long period of time.

- Overall, the highest concentrations of microorganisms occurred in samples from static pile composting systems; the lowest concentrations were found in pelletized sludge from a heat drying process. Microorganism densities in aged anaerobically digested-air dried sludges were as low as, or lower, than most of the composted sludges.
- Composts from the windrow facility sampled weekly that were modified with various materials to produce commercial soil amendments contained significantly higher concentrations of bacteria and fungi than the base compost material. The data suggested a nutrient-related regrowth phenomena.
- Potentially pathogenic bacteria, including *Salmonella* sp., *Yersinia* enterocolitica and toxigenic *E. Coli* were detected. *Salmonella* sp. were the most frequent pathogen detected. The quantitative test for toxigenic *E. Coli* indicated that these strains, when present, occurred at very low levels. However, the percentage of colonies that were toxigenic strongly suggested that the concentration of toxigenic strains was much higher than indicated. *Yersinia enterocolitica* occurred at very high densities in some samples. The isolation of *Yersinia* was consistent with a seasonal occurrence, with the prevalence and density higher in colder months. Based on a small number of tests the *Yersinia* appeared to be avirulent (not causing disease).
- Given the considerable variation observed in microbial densities and the reasonably frequent isolation of *Salmonella*, bacterial monitoring to assure product quality may be of value for the home use of sludge and compost soil amendments. Regression analysis suggested that total or fecal coliforms or fecal streptococci may be suitable indicators for monitoring.

It was also concluded that the occurrence of pathogenic bacteria could present a potential health problem under certain circumstances. There is, however, a discussion in the report about how the windrow facility has been able to modify its composting practices to essentially eliminate the occurrence of *Salmonella* (see below).

PUBLIC HEALTH EFFECTS

The report states that the extent of risk associated with the use of sludge products has not been determined. However in conversations with California health officials and EPA representatives (as well as a literature search), the researchers found no reports of anyone ever getting sick from using a sludge compost-based fertilizer or soil amendment product. What is not known is whether or not there is any measurable risk of infection associated with using products containing the levels of *Salmonella* detected in this study.

The report included some discussion on the health significance of *Salmonella* and *Yersinia*:

"Rates of *Salmonella* infections have been increasing in the United States in recent years. Salmonellosis clearly remains a disease of concern. Nevertheless, the salmonellae are fairly ubiquitous and it is common knowledge that salmonellae may be found in food products such as chicken and turkey. The World Health Organization (1981) has suggested that it may be impossible to eliminate salmonellae from the environment and that the best control measures may be increased education about food handling practices.

"It is difficult to assess the potential health significance of the salmonellae detected in the compost products. There are no known cases of salmonellosis traceable to the use of sludge based soil amendments. The studies by Ottolenghi *et al* (1987) found no apparent risk to farm families using anaerobically digested sludges in agricultural applications. These sludges were shown to contain salmonellae. Available data suggest that salmonellae may persist in sludge amended soil for up to five months but that a 90% reduction occurs within three weeks (Sorber and Moore 1986). There is some evidence that specific *Salmonella* serotypes may selectively grow in compost and that these strains are less commonly associated with clinical infections (unpublished data).

"All of these factors appear to mitigate the health significance of the salmonellae data. At the same time the question raised by these results should not be ignored. Additional research to better understand the reasons for the high salmonellae levels is warranted. Relatively simple management practices may significantly alleviate any potential hazards associated with salmonellae in compost."

To further understand the health significance of *Yersinia*, the San Jose Creek Water Quality Laboratory contracted with the New York State Department of Health to do a characterization of some *Yersinia* isolates. The isolates were non-pathogenic, suggesting that the high levels of this organism detected at the static pile site probably do not constitute a public health risk, however, the number of isolates actually tested for pathogenicity was very small relative to the quantity of *Yersinia* measured in some compost samples. These data do not definitively establish that virulent *Y. enterocolitica* were or were not present or that sludges do or do not serve as a reservoir of pathogenic *Yersinia* strains. Additional research will be necessary to fully address these questions and understand the ecology of *Yersinia* in affected sludge treatment systems.

IMPROVING COMPOSTING RESULTS

The data showed a higher occurrence of mi-

croorganisms in the static pile products overall. This should not be viewed as an indictment of static pile systems, per se. In fact, one of the static pile facilities sampled had very low densities of microorganisms. The reasons for these differences could not be determined from this study. The project author has seen a correlation between the amount of attention paid to the windrow composting process by the operators and the quality—microbiologically—of the final compost product. This suggests the need for good operator training and operation manuals.

While the research did not determine what caused the variations in pathogen *(Salmonella)* levels, it was subsequently found that more complete composting lowers overall microorganism densities and results in a compost product in which *Salmonella* regrowth is minimized. Monitoring for specific indicator microorganisms seemed to reflect this point. Therefore, monitoring or testing might be needed in addition to current guidelines to ensure that pathogenic bacterial levels are adequately reduced.

A voluntary coliform monitoring program to indicate the potential for *Salmonella* regrowth was instituted at the California windrow facility. In addition to meeting minimum recommended time and temperature requirements, compost there is not released to the marketing agent until total coliforms have been reduced to a median most probable number (MPN) of 10/gram dw. or less (based on recommendations published by Roger T. Haug in *Compost Engineering, Principles and Practice;* 1980). No more than 20 percent of the samples can have greater than 1,000 MPN/gram and no single sample can be greater than 10,000/gram. If the median number is above 10 per gram, composting of that windrow is extended for a week to 10 days, after which the material is retested. If a windrow does not meet the 10 MPN/gram median coliform level after two or three extensions, a test for *Salmonella* is conducted; to date, that has occurred very infrequently. The windrows are released if the results of the *Salmonella* test are negative.

WHAT NEXT?

A more comprehensive epidemiological study—actually examining people using compost—might be useful to draw more definitive conclusions about the health effects of using sludge compost-based fertilizer products. Even though that could be a logical step to take, the standard epidemiological study is expensive and very difficult to do. A much less costly alternative would be for composting facilities to do selective monitoring for indicator microorganisms and to modify composting practices where needed.

In conclusion, the authors of this article are very encouraged that there were no significant problems with viruses and parasites—major groups of organisms that were thought could be a problem. Most of the major classes of pathogens that the Water Quality Laboratory looked for were absent. And

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COMPOSTING PROJECTS FOR GRASS CLIPPINGS

WHILE leaf collection has received more attention from municipal composting efforts, many communities are beginning to target grass clippings in their recycling campaigns.

Of the 20 some communities in Wisconsin listed by the Bureau of Solid Waste Management as "composting communities," about a fourth of them collect and compost grass clippings too. Monroe, Wisconsin is enthusiastic about collecting and composting grass clippings along with leaves. "Mixed together, the two make a better compost than either separately," says Nate Klassy, street superintendent. There is less compaction in the windrow, which helps to keep the pile from becoming anaerobic and generating odors.

To collect the clippings, a packer truck follows the garbage truck, and workers pick up the bags of clippings, dump them in the truck, and stack the bags separately. "We collect between 6,000 and 12,000 lbs of clippings a day," says Klassy. Clippings are piled on land the city owns adjacent to the airport runway, and eventually mixed with leaves for composting. "We deliver the finished compost free by the truck load. The park department takes quite a bit."

Omaha, Nebraska is in its second year of a three year pilot program on composting grass clippings. "The project is very small scale, so far," says Marty Grate, a city employee. "We started with one community of approximately 350 people on a voluntary basis. About half—170—cooperated, which we thought was very promising. The waste hauler, Watts Trucking, who wanted the learning experience too, was also extremely cooperative. He made the second collection each week essentially free."

One reason homeowners cooperated voluntarily, Grate believes, is because of two advantages the city could offer. The first was Monday pickup, rather than the usual Friday pickup. "Most people mow their lawns on weekends and don't like having the clippings around all week long," explains Grate. Secondly, the city rented the homeowners 90 gallon, plastic wheel carts at a nominal cost, to load the clippings in. "They didn't have the cost or bother of plastic bags."

This year, Omaha will expand the program to a community of 800, on a voluntary basis. "It looks like we'll have about 500 cooperators," says Grate. The city works with homeowner associations to get the programs going—in fact, it was a homeowner association that approached the city in the first place, recalls Grate. After discussing the projects with the associations, the city then sent mass mailings to the community, explaining the program and asking for cooperators. "Early week pickup and no bags sells the program pretty well," he says.

The clippings are piled at the landfill, and are used for cover as needed. The city has not explored selling or returning the composted clippings to citizens. Grate has not noticed any appreciable odor either when the clippings are dumped at the site or when they are loaded into the tub grinder with leaves and brush. Having the brush in the mixture increases the porosity in the pile and keeps the material from becoming anaerobic.

The carts used in the pilot program cost about $60 retail, depending on the number ordered, and are very popular for wheeling the trash out to the curb rather than carrying plastic bags, points out Mike Schnelle of Solid Waste Equipment Co. in Omaha, a distributor of the " Polycart" made by Pawnee Products in Goddard, Kansas. "They double as a garden cart—the wheels are 12" in diameter—and have replaceable bins," he says. "We've got about 400 of them out in the city now." ■

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PATHOGEN LEVELS

(Continued from page 47)

although the study did find a potential problem with *Salmonella*, it appears to be a situation that is correctable. ■

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A project summary of the report is available from CERI U.S. EPA, Cincinnati, OH 45268 (EPA/600/S1-87/014).

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